Seasonal Changes in the Body Component Indices of the Subtidal Prosobranch *Fusitriton oregonensis*

BY

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(2 Text figures)

INTRODUCTION

Seasonal changes in several body component indices of the intertidal prosobranch *Thais lamellosa* (Gmelin, 1791) were related to prey availability (Stickle, 1973). Emlen (1966) has shown the ability of *T. lamellosa* to prey upon the barnacles *Balanus glandula* Darwin, 1854 and *B. cariosus* Pallas, 1788 to be related to both barnacle size and position in the intertidal zone. The snails feed only when submerged and are not submerged long enough to drill through large *B. glandula* located high in the intertidal zone (Connell, 1970). The large barnacles in the narrow "refuge" zone at the top of the intertidal zone produce enough young to repopulate the intertidal zone each spring. Young barnacles are eliminated by predation in all but the "refuge" zone by late autumn.

One way of evaluating the effect of prey availability upon nutrient accumulation of predators would be to study seasonal changes in the body components of a species which has adequate supply of prey year around. The subtidal prosobranch *Fusitriton oregonensis* (Redfield, 1848) was chosen because of its generalized feeding habits and large size which makes it possible to dissect many components from the soft parts.

Fusitriton eats a variety of invertebrates including echinoids, ascidians, amphineurans, prosobranchs, and pelecypods. The most active feeding period is at night. The green sea urchin, *Strongylocentrotus drobachiensis* (O. F. Müller, 1776) was observed to be the most common prey of *F. oregonensis* in the field (Eaton, 1971). The species has been observed scavenging, perhaps as a result of having killed its prey the night before. An ample food supply is probably always available to these snails.

Fusitriton oregonensis is found on the west coast of North America from Alaska to Mexico. The species rarely occurs in the intertidal zone but is found in considerable numbers in 2 m to at least 180 m depth.

Fusitriton oregonensis is one of the most advanced mesogastropods. It has a well developed reproductive system with which it deposits its eggs in capsules which look like kernels of corn. Egg capsules are usually laid on rock surfaces and when females are uncrowded, the capsules are arranged in a circular egg mass of up to 100 capsules (Eaton, 1971; Howard, 1962).

The reproductive behavior of *Fusitriton oregonensis* has been documented by Eaton, 1971. Pair formation begins approximately 6 months prior to egg laying. Egg laying begins in June or July and is signalled by a behavioral change of females which remain on the breeding aggregation during the day instead of in crevices or at the bases of rocks. If males are found near the aggregation they are located around its periphery. Females normally brood the eggs from the time the capsules are laid until the last one has hatched 8 - 9 weeks later. Eaton found this brooding behavior to prevent capsule predation.

METHODS AND MATERIALS

Fusitriton oregonensis were periodically collected from April 24, 1969 to June 5, 1970 at Edwards Reef off the west coast of San Juan Island, Washington. Collections were made with SCUBA gear in 10.6 to 18.3 m of water. Field observations were made by Stickle through August 1969. After being taken to the Friday Harbor Laboratories, animals were frozen and then shipped to Slippery Rock State College for analyses.

Component Indices: - Animals were thawed, the outer shell blotted dry, and the entire animal was weighed. The

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shell and operculum were removed, and excess water was wiped from the soft tissue before it was weighed. The animals were then sexed and separated into the following soft body components: gonad-digestive gland, capsule-albumin gland or penis, kidney, mantle, foot and remaining visceral mass. The foot was dissected from the remainder of the parts by cutting along a line from just in front of the 2 tentacles to the posterior edge of the opercular scar. The gonad-digestive gland, kidney, mantle, capsule-albumin gland, and remaining visceral mass components were dissected free in their entirety. The penis was dissected free at its base. The soft components were dried to constant weight at 90 - 100° C. Body component indices were calculated as in an earlier study (STICKLE, 1973). Each index was expressed as grams of the component per grams of the entire animal times 100.

Statistical Analyses - All data are given as the mean ± the 95% Confidence Interval.

RESULTS

Field Observation - *Fusitriton oregonensis* were scattered in the study area on June 2, 1969. One female was observed to be laying eggs on July 1, and many females were aggregated and laying cases on July 22. Animals were still aggregated when collected on August 23. No males were found among the animals collected on July 22 and August 23.

Component Indices - Female kidney, mantle, foot, shell, and body water index data are given in Table 1. No seasonal pattern was observed with respect to changes in the magnitude of any of these indices. An inverse relationship existed between the shell and body water indices throughout the study.

Data for the female ovary-digestive gland and capsule-albumin gland indices are depicted in Figure 1. The termination of the breeding aggregation was estimated to be about September 15 by using EATON's (1971) estimate of an 8 - 9 week developmental period for the embryos. The ovary-digestive gland index declined from an average June 2 value of 4.83 to 2.85 on August 23. This index did not reach the same magnitude in 1970 that it did in 1969. The capsule-albumin gland index exhibited a distinct seasonal pattern. It declined from 1.96 on July 1 to 0.68 on August 23. The capsule-albumin gland index increased to near its 1969 prespawning magnitude by May 1970.

Remaining visceral mass index data are depicted in Figure 2. Highest levels were found in April, January, and February. A sharp drop occurred in the index between April and June 1969, which was not repeated in 1970.

The average index of each female body component exhibited the following seasonal range: kidney, 0.29 - 0.37; mantle, 0.43 - 0.62; foot, 1.16 - 1.46; capsule-albumin gland, 0.68 - 1.96; remaining visceral mass, 2.77 - 3.82; ovary-digestive gland, 2.85 - 6.02; body water, 25.55 - 30.28; and shell, 57.66 - 65.31.

Male kidney, mantle, foot, penis, testis-digestive gland, body water, and shell index data are given in Table 2. No seasonal pattern was observed in the magnitude of any of these indices. An inverse relationship existed between the body water and shell indices throughout the study.

Table 1

Seasonal Body Component Indices of Female *Fusitriton oregonensis*
g x 100g Animal^{-1} x 100

Date	Sample Size	Kidney	Mantle	Foot	Body Water	Shell
24/ IV/1969	9	0.36±0.03 [1]	0.62±0.10	1.41±0.11	29.10±2.06	57.66±3.03
2/ VI/1969	11	0.31±0.05	0.48±0.07	1.25±0.11	25.55±1.38	62.90±1.79
1/ VII/1969	6	0.33±0.05	0.50±0.16	1.15±0.15	27.64±2.32	60.63±2.03
22/ VII/1969	28	0.38±0.03	0.43±0.03	1.31±0.06	28.97±0.82	61.61±1.00
23/VIII/1969	24	0.37±0.04	0.43±0.02	1.34±1.28	26.14±0.86	65.31±0.84
10/ X/1969	8	0.29±0.08	0.55±0.12	1.34±0.10	26.55±1.97	63.74±3.47
16/ XI/1969	15	0.31±0.05	0.52±0.10	1.46±0.11	28.95±2.26	60.15±1.34
24/ I/1970	6	0.29±0.05	0.45±0.10	1.17±0.08	30.28±1.64	58.97±3.41
20/ II/1970	11	0.30±0.06	0.52±0.08	1.38±0.15	29.61±1.08	59.50±2.03
19/ III/1970	10	0.27±0.04	0.49±0.07	1.23±0.08	28.61±1.67	61.27±2.71
6/ V/1970	10	0.35±0.06	0.50±0.07	1.20±0.10	28.32±1.35	60.18±2.11
5/ VI/1970	7	0.29±0.04	0.49±0.08	1.16±0.16	28.16±1.81	61.11±3.68

[1] Mean ± 95% confidence interval

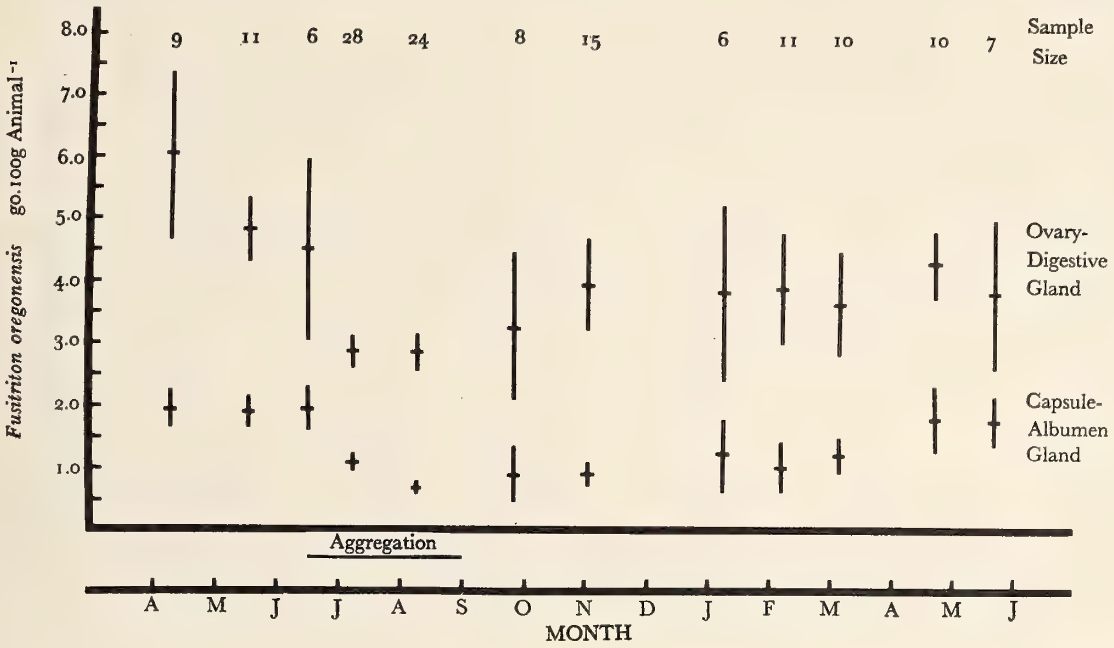

Figure 1

Female ovary-digestive gland and capsule-albumin gland indices are represented by crosses. The horizontal line of each cross represents the mean and the vertical line the 95% confidence range about the mean.

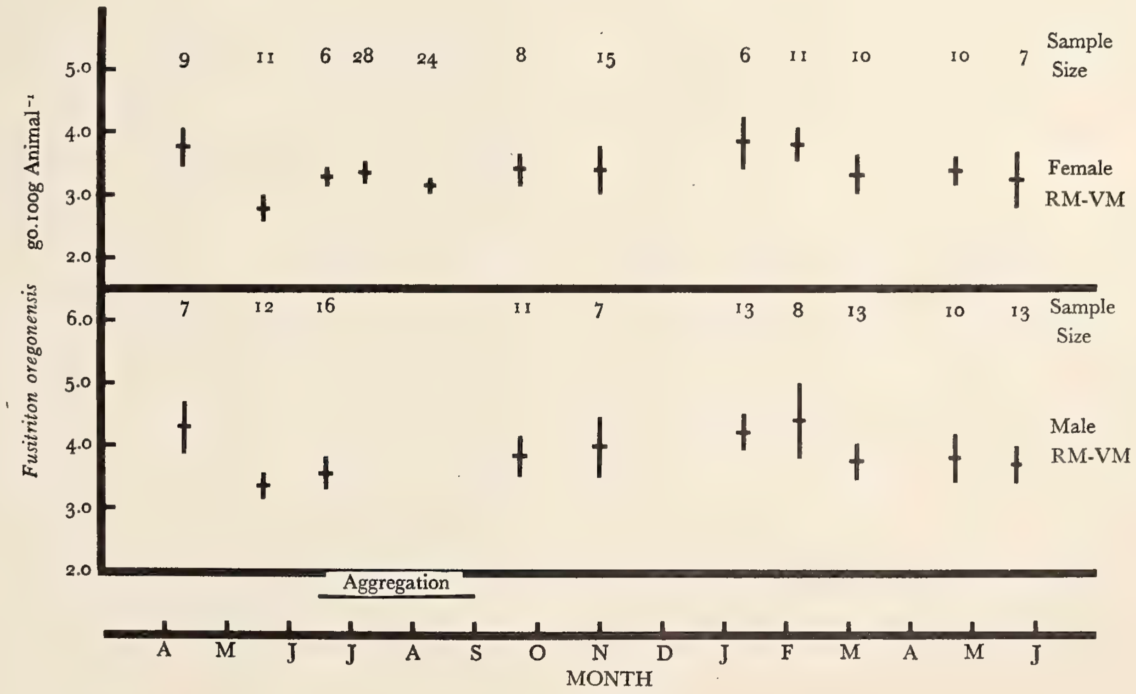

Figure 2

Remaining visceral mass indices of both sexes are represented by crosses. The horizontal line of each cross represents the mean and the vertical line the 95% confidence range about the mean.

Table 2

Seasonal Body Component Indices of Male *Fusitriton oregonensis*
g x 100 g Animal^{-1} x 100

Date	Sample Size	Kidney	Mantle	Foot	Penis	Body Water	Shell
24/ IV/1969	7	0.36±0.07 [a]	0.69±0.07	1.60±0.09	0.45±0.04	29.16±1.74	59.31±2.38
2/ VI/1969	12	0.32±0.04	0.53±0.08	1.53±0.14	0.42±0.04	25.57±1.53	64.64±2.20
1/ VII/1969	16	0.28±0.03	0.59±0.06	1.32±0.09	0.40±0.04	27.56±1.49	63.24±1.89
22/ VII/1969	0	....	....	....	....	....	....
23/VIII/1969	0	....	....	....	....	....	....
10/ X/1969	11	0.26±0.04	0.57±0.08	1.50±0.14	0.42±0.06	28.89±1.71	60.62±2.62
16/ XI/1969	7	0.33±0.08	0.61±0.09	1.65±0.25	0.43±0.07	29.24±1.25	59.96±2.03
24/ I/1970	13	0.30±0.03	0.56±0.08	1.42±0.09	0.43±0.06	28.97±1.95	60.35±2.44
20/ II/1970	8	0.32±0.05	0.59±0.10	1.39±0.15	0.41±0.05	28.46±2.37	60.81±3.38
19/ III/1970	13	0.24±0.02	0.53±0.05	1.37±0.12	0.40±0.07	28.32±1.44	62.40±2.02
6/ V/1970	10	0.26±0.04	0.63±0.12	1.35±0.09	0.39±0.08	28.32±1.10	62.15±1.74
5/ VI/1970	13	0.29±0.04	0.67±0.08	1.36±0.12	0.43±0.05	28.96±1.57	61.21±2.34

[a] Mean ± 95% confidence interval

Male remaining visceral mass index data are given in Figure 2. The same seasonal pattern was observed with the male remaining visceral mass index as was observed with the female component.

The average index of the male body components exhibited the following seasonal range: kidney, 0.24 - 0.36; penis, 0.39 - 0.45; mantle, 0.53 - 0.69; foot, 1.32 - 1.65; remaining visceral mass, 3.58 - 5.40; testis-digestive gland, 2.93 - 4.14; body water, 25.57 - 29.24; and shell, 59.31 to 64.64.

DISCUSSION

The female ovary-digestive gland and capsule-albumin gland indices of *Fusitriton oregonensis* and *Thais lamellosa* exhibited a distinct seasonal cycle. Indices for both components were larger for *F. oregonensis* and the indices declined more on an absolute basis than for *T. lamellosa* during spawning. However, the fact that the shell index is much larger in *T. lamellosa* than in *Fusitriton* probably explains the difference in the magnitude of the respective indices.

About the same percentage of the prespawning capsule-albumin gland index remained at the completion of spawning for the two species: 35% for *Fusitriton*, and 27 - 30% for *Thais*. However, 59% of the prespawning ovary-digestive gland index remained at the completion of spawning for *Fusitriton* as compared to only 26 - 33% for *T. lamellosa*. Biomass was lost from the ovary-digestive gland for both species as a result of spawning and catabolism by the female during aggregation. Aggregation was more than a month longer for *T. lamellosa* than for *F. oregonensis*. In addition, more biomass must be deposited per embryo of *T. lamellosa* than for *F. oregonensis* because development is completed in the capsule of *Thais*, but a free swimming veliger is released from the egg capsule of *Fusitriton*. It is impossible to estimate the total biomass lost by female *Fusitriton* for the production of spawn because there are no data available on egg or egg capsule production per female. Such data do exist for *T. lamellosa* (SPIGHT, 1972) and STICKLE (1973) has made the necessary calculations.

No body component of male *Fusitriton oregonensis* exhibited a seasonal cycle. In contrast, the testis-digestive gland index of *Thais lamellosa* exhibited a distinct seasonal cycle (STICKLE, 1973). However, *T. lamellosa* males accompany the females to the breeding aggregations where copulation occurs. Males copulate and starve for the better part of the 3 to 4 month aggregation period. Pair formation occurs approximately 6 months prior to egg laying in *F. oregonensis* (EATON, 1971). Copulation is intermittent and begins 4 months prior to egg laying. Eaton observed the percentage of *F. oregonensis* to be paired at Edwards Reef as follows: April - 43%, May - 62%, and June - 38%. The duration of individual pairs in the laboratory was highly variable. Many lasted only 1 or 2 days, while others remained together for as long as

28 days. Eaton states that there is a good chance that pairs found in nature are of a generally longer duration. This study indicates that male *F. oregonensis* feed often enough during the 4-month copulatory period to replenish biomass lost from the testis-digestive gland through copulation and respiration.

The decline in the remaining visceral mass index of both sexes between April and June 1969 cannot be explained at this time. The proboscis and salivary glands of *Fusitriton* account for much of the biomass of the remaining visceral mass. Seasonal changes in the size and physiology of gastropod salivary glands are in need of investigation.

The body components of *Fusitriton oregonensis* more closely resemble those of *Thais lamellosa* (Stickle, 1973) than those of *Haliotis cracherodii* Leach, 1814 (Giese, 1969; Webber & Giese, 1969; Webber, 1970), *Megathura crenulata* (Sowerby, 1825), or *Polinices lewisii* (Gould, 1847) (Giese, *op. cit.*). However, the reproductive behavior of *F. oregonensis* is much different from that of *T. lamellosa*. This fact is responsible for some of the differences in the pattern of biomass accumulation observed between males of the two species.

Differences in prey availability do not effect the similar pattern of biomass accumulation in the reproductive tract of female *Thais lamellosa* and *Fusitriton oregonensis*. However, differences in the biochemical characteristics of the reproductive tract of the two species may account for the different chemical composition of the respective egg capsules. The egg capsules of *T. lamellosa* are composed of 51% protein, 13% lipid, and 2% polysaccharide as compared to 24% protein, 11% lipid, and 2% polysaccharide in *F. oregonensis* egg capsules (author's unpublished data). Protein must be accumulated in much higher concentrations in the reproductive tract of *T. lamellosa*.

SUMMARY

1. Body component indices of *Fusitriton oregonensis* were determined over a period of 15 months. Snails were separated into shell, body water, gonad-digestive gland, capsule-albumin or penis, kidney, mantle, foot, and remaining visceral mass. Indices were expressed as grams of the component per gram of the entire animal times 100.

2. The female ovary-digestive gland and capsule-albumin gland indices exhibited a distinct seasonal cycle of being largest in the several months prior to aggregation, declining during that period, and increasing several months prior to the next aggregation.

3. No body component of the males exhibited a seasonal cycle. Males apparently feed often enough during the 4-month copulatory period which precedes aggregation to replenish biomass lost through copulatory activity. No males were collected from the breeding aggregation.

4. It does not appear that seasonal differences in prey availability are responsible for the accumulation of biomass in the reproductive tract of female *Fusitriton oregonensis* during the several months prior to aggregation. It is likely that some endogenous factor is responsible for this fact.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Gordon Robilliard for collecting animals for us from September, 1969 to June, 1970. This research was partially funded by a National Research Council of Canada research assistantship granted to W. B. S. and in part by S. R. S. C. Biology funds.

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